NKO3 Ballast Water Treatment Systems

EXHIBITS Vol. II

TEST AND INSPECTION RECORDS & REPORTS

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Part I Full Scale Onboard Test

1 Prince William Sound

1.1 Approval of Installation Plan

1.2 Experimental Design

1.1 Approval of Installation Plan

ABS
AMERICAS DIVISION

CAJ
OPN: 1575538
Ref: 164057

26 May 2006
PRINCE WILLIAM SOUND, ABSID: 7521140
Sun Shipbuilding & Drydock Co., Hull: 667
Dwg. No. None, Mark III Series Ozone System
For Ballast Water Treatment
ACP Vessel

Netsco., Inc.
11700 Station Road
Columbia Station, OH 44028

Attention: Mr. Richard A. Mueller

Gentlemen:

We received your letter dated 01 May 2006 submitting copies of plans as listed therein on the above subject and with regard thereto have to advise that insofar as our requirements for Classification are concerned, the arrangements and details as indicated appear to be satisfactory in association with the attached comment P-001. Please note that this approval is valid only until IMO guidelines are implemented.

The plan has also been reviewed for compliance with the "U.S. Supplement to ABS Rules for Steel Vessels for Vessels on International Voyages" (1 August 1998 Edition) in accordance with U.S. Coast Guard Navigation and Vessel Inspection Circular (NVIC) 2-95, "U.S. Coast Guard's ABS Based Alternative Compliance Program". The arrangements and details as indicated are approved subject to the work being carried out to the satisfaction of the Surveyors and the attached comment.

An invoice to cover the cost of our review will follow. Please forward your remittance as per instruction on the invoice.

One (1) copy of the manual appropriately stamped is being returned.

If we can be of any further assistance, please contact Christopher Johnson at (281) 877-6128, or the undersigned at (281)-877-6744.

Very truly yours,

Pradeep Rai
Principal Engineer
Ship Engineering Department

cc: ABS Singapore
USCG (MSC), Washington, D.C.
USCG ACP Hold
Project Correspondence File

ABS PLAZA, 16855 NORTHCHASE DRIVE, HOUSTON, TX 77060-6008 USA
TEL: 1-281-877-6000 FAX: 1-281-877-6001 EMAIL: abs-amer@eagle.org

LISTING OF COMMENTS IN OPEN STATUS

Project Number : 1575538
Project Hulls : SUN SHIPBUILDING & DRYDOCK CO., 667
Review Activity : Ship - Bilge and Ballast Systems

Thread Number : P-001
Submittal Items : NONE - PRINCE WILLIAM SOUND BALLAST WATER TREATMENT

Comment Text	Task No	Action	Published Date
The attending Surveyor is requested to verify that the hose is of an ABS approved type and is suited for the intended service.	164057	Surveyor	31-MAY-2006

TOTAL NO : 1

1.2 Experimental Design

Experimental Design

Preface

This protocol is not a "stand-alone" document and is provided for consideration keeping in mind the following:

1. The legislation that provided for this funding specified that experiments be conducted on board an operational ship.

2. The experimental design builds on the results obtained aboard the *S/T Tonsina*

3. The protocol covers studies to be conducted on-board the *S/T Prince William Sound.*

4. The ozone generator and single point injector are standard design and pilot studies are being conducted prior to full-scale installation.

5. Supporting material is provided in the Appendices.

Ⅰ. Introduction

The introduction of non-native coastal species across the bio-geophysical barriers of the ocean by ships through the discharge of contaminated ballast water is of great ecological and economic concern. The introduction, for instance, of zebra and quagga mussels into the Great Lakes via the discharge of ships' ballast water has led to irreversible ecological damage, has had devastating economic consequences, and has led to secondary infestations into the Mississippi River and its tributaries. Similar discharges have destroyed commercially important shellfish populations in the Chesapeake Bay.

Ballast water exchange at sea has been shown to be highly variable in its effectiveness and no other "benchmark" has been available. Initial studies included ballast water exchange as the "benchmark" to test effectiveness of the new process that is the subject of on-going testing.

However, in the proposed study no exchange studies are planned. Rather our approach will be to evaluate removal efficiency based on the collection of samples prior to and after ozonation.

Among the possible treatment technologies, ozonation stands out as an environmental friendly technology. The ozone residual, although short-lived, is a powerful disinfectant, while its reaction with bromide in seawater results in a longer-lasting residual of bromine (in water HOBr/OBr -). The synergistic effects of ozone and bromine have been shown to result in invasive species control with minimal ecological effects. The resulting bromine disinfectant residual is measured and expressed as the total residual oxidant (TRO). Much of this research program is focused on the biological and chemical effects of the TRO. The efficiency of the ozone transfer system and its operation using a full-scale system installed aboard the oil tanker *S/T Prince William Sound* will be tested while the ship is operating under normal conditions.

Ⅱ. Objectives

The main goal is to establish the treatment efficacy of the ozone process under normal ship *(S/T Prince William Soun*d) operations with the view of preventing the transfer and release of non-indigenous species. To achieve this goal, four treatment objectives are identified:

Treatment Objectives

- To achieve absolute treatment efficiency by comparing concentrations of viable organism concentrations before and after treatment.
- To determine practical operating conditions and control guidelines for ozonation of ballast water, under normal ship operations.
- To develop an understanding on the potential environmental effects of disposal of the treated ballast water.
- To obtain design criteria for shipboard ozonation during operation at 10,000 gpm.

Ⅲ. Tasks

To accomplish the objectives, this study is divided into four areas as described below.

A. Total residual oxidant (TRO) kinetics

This portion of the study will follow from the studies conducted earlier and reported in Appendix A, a paper submitted to *Marine Pollution Bulleti*n.

1. Determine the rate of decay of TRO in ballast waters at full scale using seawater obtained from different ports along the U.S. West Coast.

2. Confirm that TRO is an acceptable control parameter for ozone treated ballast water for ocean-going vessels.

B. Biological effectiveness of ozone for ballast water treatment

1. Conduct three full scale experiments to assess the efficacy of ozone treatment of ballast water by determining the concentration of viable organisms at several trophic levels. These studies will be guided by the results of our past research on the *S/T Tonsina* as well as emerging IMO and other standards.

2. Perform a limited study of bacterial pathogens and indicator organisms under controlled laboratory conditions. For example, *Vibrio cholerae* or appropriate surrogates will be exposed to various concentrations of TRO and their survivability will be assessed.

C. Effluent discharge testing

1. To conduct laboratory studies using whole effluent testing (WET) guidelines for assessing the potential acute environmental toxicity of TRO. **(Appendices B and** C)

2. To expand the number of species that are studied to determine chronic toxicity levels of TRO to evaluate the environmental safety of ozonated ballast water prior to discharge and to generalize the results.

D. Engineering and industrial health aspects of ozonation

1. To study the efficacy of ozone transfer using single point injection in a shipboard

environment.

2. To establish the proper shipboard construction procedures for ozone equipment and operating protocols for this equipment.

Ⅳ. Considerations

1. The *S/T Prince William Sound* has a ballast system arrangement that permits one series of treatment and one of control tanks. Its ballasting system uses two pumps (each 10,000 gpm, gallons per minute), which are segregated from each other. One pump serves the forward-most set of ballast tanks, and the other pump serves the after ballast tanks. The ozone system and injection will be fitted in one of the two pumping lines that will serve as the treatment series of tanks. The other pump and associated ballast water tanks will have no ozone injected and the ballast tanks for this pump will serve as the control series of tanks.

2. The goal will be to minimize the impact on the vessel that is being used for these experiments while still maximizing the number of experiments that are completed in the time and funding that is available.

Ⅴ. Experimental Considerations

A. Organisms to be studied – Trophic levels

The target organisms to be tested in these experiments are the indigenous organisms that are found at the ports of call for the ship (**Appendix** D). The ports where ballast water is routinely collected are Long Beach, San Francisco, and Puget Sound. No studies will be conducted on the ship where organisms are spiked into the ballast water tanks. No non-indigenous organism (other than those that may already have been established in the port) will be used in any of the ship board studies.

a. Bacteria

b. Phytoplankton
c. Zooplankton
   Microzooplankton
   Mesozooplankton
   Megazooplankton

Bacteria and phytoplankton samples will be collected from the sampling ports and lines that are installed in the ballast tanks that will contain treated (ozonated) and control ballast water. Water will drawn from these locations with the aid of a pneumatic pump. If necessary, samples for bacteria, phytoplankton, and chemical analyses will be collected with a Niskin oceanographic sampler.

Zooplankton net tows will be performed using a 50-μm mesh net. Recent IMO and U.S. legislative initiatives propose standards that limit the discharge of viable organisms that are 50 μm or greater in size. Previous work on board the *S/T Tonsina* and in laboratory studies was performed with a 73-μm mesh net. By reducing the mesh to 50 μm, it is very likely that a greater concentration of the smaller stages of organisms will be collected in the sample tow. The smaller organisms in the 50 μm and greater fraction may not be easily identifiable to species and their viability may be more difficult to determine using the "pick and prod" method, the procedure we previously used to characterize organisms greater than 73 μm as "live, moribund, or dead".

The University of Washington research team is now evaluating and comparing the differences in results obtained by using a 72 versus a 50-μm mesh net for zooplankton collected from Puget Sound and from the ballast tanks of ships arriving in Puget Sound.

B. Control Studies

Control studies will consist of sampling the ballast water to which no ozone has been added. This untreated seawater will be placed in control ballast tanks. The sampling times, chemical and biological evaluations will be the same as for samples collected from ballast tanks containing ozonated seawater.

C. Time Course

1. TRO decomposition with time will be evaluated for the ballast water on several

voyages. Ideally, we would like to examine the fate of the TRO for ballast water separately obtained from Long Beach, San Francisco Bay, and Puget Sound, the three major ports that the *S/T Prince William* Sound visits. This will then allow the use of concentration-time (CT) analyses of ballast water possible for comparison to values determined from other applications (such as water and wastewater treatment).

2. From studies conducted both in the laboratory and previous testing aboard the *S/T Tonsin*a, the inactivation of bacteria, phytoplankton and zooplankton appears to be complete at the end of the ozonation of the ballast water. These previous experiments used a diffuser technology that required that the ballast water tank be filled prior to ozonation. Ozone was introduced through porous diffusers and once the ozone system was turned on it was operated for 5 or 10 hours to reach the target residual TRO. Samples were taken at different times during and following ozonation to obtain data on efficacy of the system (kill rate).

3. Single point injection as planned for the experiments on board the *S/T Prince William Sound* will essentially provide a TRO instantaneously as the ballast tank is filled. Sampling during the fill process is not envisioned. Initial and focused studies will be conducted to sample immediately upon fill and subsequently with time to determine whether this approach is necessary during each ship-board experiment.

D. Chemical Characterization of Water Quality

Extensive studies have been conducted under previous and on-going studies aboard the *S/T Tonsin*a. For experiments onboard the *S/T Prince William Soun*d, initial baseline data will be obtained for the different waters, defining the water quality.

1. Studies we have published indicate that little, if any, variation occurs in most of the normal water quality parameters. Minimal additional studies will be conducted during this project with respect to the normal water quality.

2. The dissolved oxygen (DO) concentration increases during ozonation. Experiments will be conducted to determine the increases in DO resulting from the injection of ozone. Saturation with oxygen under pressure immediately after ozonation and subsequent pressure equalization in the ballast tank is expected to contribute to disinfection and help to maintain desirable aerobic conditions in the ballast tanks.

H. Ozone transfer studies

Ozone is a sparingly soluble gas resulting in less than complete dissolution. Ozone gas measurements, in gas samples after ozone contact and that escaping from the ballast tank vents will be conducted. This will follow established methods used in the field of industrial hygiene. This will also determine the efficacy of ozone transfer and help establish design criteria for future applications.

VI. Sampling

Sampling access locations immediately prior to and following the ozone injection and multiple sampling lines located in the vertical and horizontal ballast tanks will be installed. A similar sampling design was implemented in our *S/T Tonsina* shipboard experiments.

1. Sampling ports will be provided at the ballast water intake prior to ozone treatment, as well as at the point of ozone treatment, and immediately at the post-treatment point. However, under normal operations this space is "off-limits" and therefore, arrangements for sampling need to be made.

2. Two of the treatment ballast water tanks will be fitted with flowing water lines, seven total sampling points, four in the vertical portion of the tanks at 15, 30, 50 feet below the deck, and near the bottom of the tank; and three points in the horizontal section. One of the control ballast water tanks will also be fitted with the same sampling configuration and will serve as the zero and timed control for sampling. The sampling lines will be used for:

   a. Bacteria analyses

   b. Phytoplankton analyses

   c. Chemical analyses

3. To sample for zooplankton it will be necessary to use vertical plankton tows. (These organisms can avoid the opening of a sampling tube and therefore a non-representative sample would be collected.) Typically one treated and one control ballast water tank will be sampled and they will be the same tanks that are used for the other (see above) tests being conducted.

4. Niskin bottles (if necessary) will be used to complement the installed sampling lines. However, we intend to minimize this sampling methodology in the interest of time and personnel requirements.

5. We would like to sample ballast water as it is being discharged. A sampling port will be installed in the S/T Prince William Sound's ballast water discharge line. A final decision on this will be ultimately determined by the ABS and Coast Guard. Seasonal and tidal effects should be factored in if possible to maximize the number of different taxa sampled. Tidal effects will be dependent upon the vessel's operation schedule and will not be controlled experimentally.

Ⅶ. Analyses

1. Ship Board

A portable laboratory on the ship near the ozone generator is planned. This will allow maximum flexibility and minimize the impact on the ship's operation. The analyses that would be conducted are:

a. Heterotrophic plate counts (if space is available)
b. Phytoplankton using chlorophyll *a* determination
c. Zooplankton (if space is available)
d. Chemical characterization

2. Shore Based

a. Phytoplankton (flow cytometry)
b. Bacterial and zooplankton enumeration and identification if not possible on board.

Ⅷ. Control and Monitoring

1. Incorporate both in-line measurements and individual sample analyses of the effluent (and the water in the ballast tank) to control the TRO.

2. Testing TRO similar to the use of disinfection monitoring used in drinking water.

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IX. Scientific and Engineering Questions

1. What is the halflife and expected lifetime of the ozone/total residual oxidant (TRO) in ballast tanks?

2. What is the O_2 concentration in the ballast water after ozone injection and over the course of the return voyage to Valdez?

3. How well does the in-line injection system and further contact in the ballast tanks accomplish the objective of inactivating taxonomically diverse groups of organisms that are found in West Coast ports?

4. Are there any additional requirements with respect to the design of the ozone transfer/contacting system?

5. What are the absolute numbers of the three groups of organisms surviving after various times in the treated ballast water?

6. Does the in-line injection system that is installed on the *S/T William Sound* achieve ballast water discharge standards as proposed by the IMO and in U.S. legislation?

X. Outputs

1. A comprehensive report that meets the requirements of Ministry of Maritime Affair

2. A draft journal article on the photochemical fate of the TRO and potential environmental impact of discharge.

3. A draft journal article on full-scale ozone transfer studies aboard a ship.

4. One or more draft journal articles on the effect of TRO on potential exotic species transfer and bacterial inactivation.

5. A trade journal article on the use of ozone in marine applications, with the focus on system design, and operational safety issues.

6. A draft peer review journal article on effluent toxicity, expanding the present database. (note: All draft journal articles will eventually be submitted for peer review but funding for that effort is not included in this grant)